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**Illinois Department of
Energy and Natural Resources**

ETHANOL-POWERED DIESEL TRACTOR

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Introduction

The flexible-fueled, ethanol-powered tractor is a modified IH 5288 diesel tractor that can operate on multiple fuels. The 240 hp engine is designed as a compression ignition, flexible-fuel engine (CIFFE). Both the engine and the fuel were modified to achieve the CIFFE.

Background

This CIFFE engine was developed through a joint effort of the University of Illinois departments of Agricultural Engineering and Mechanical Engineering. The Department of Mechanical Engineering developed the dual fuel system and the electronic control system. The Department of Agricultural Engineering installed the dual fuel system in the tractor, optimized the electronic control system, conducted performance testing, and subsequently modified the tractor ethanol could be used as the primary fuel using a fuel additive.

The Illinois Department of Energy and Natural Resources provided funding to develop the ethanol tractor. Additional funding was provided by Illinois corn growers through their check-off program.

Engine Modification

The original diesel injection system has been retained on the CIFFE. The fuel delivered through this original system is called the primary fuel. In addition, a system similar to the electronic fuel injection (EFI) systems on cars was added to allow ethanol to be injected into the inlet valve ports of the engine. The technique is known as fumigation; the fuel delivered through this added system is called fumigated fuel. Ethanol will not self-ignite in an ordinary diesel engine. In the initial research that developed the CIFFE, ethanol was the fumigated fuel and, by using No. 2 diesel as the primary fuel, all of the fuel could be ignited in the engine. The two fueling systems on the CIFFE are independent of each other: each system has its own fuel tank and the fuels never join until they reach the combustion chamber. The engine governor automatically provides a balance between the two fuels by reducing consumption of the primary fuel when ethanol is fumigated.

Thus, the net result of the original system was to use fumigated ethanol to reduce the consumption of diesel fuel by the engine. It was found that 70 percent ethanol could be used under light loads and up to 30 percent ethanol could be used under heavy loads. It was also found that ethanol of less than 200 proof could be used.

Fuel Modification

A new additive, Avocet, has been developed to enable ethanol to be used in diesel engines. It is marketed in the United States by ICI, Americas. Avocet contains a lubricant to enable ethanol to lubricate the primary injection system. Avocet also contains an ignition accelerator that causes the ethanol to self ignite in a diesel engine. Avocet is so powerful that it can be used in relatively low concentrations. The manufacturer recommends using it at 6 percent concentration, but the tractor currently runs on a 4 percent concentration.

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The CIFFE

If ethanol is enhanced by adding Avocet, the enhanced ethanol can be used as the fuel for any diesel engine. Because a gallon of ethanol contains only 61 percent of the energy contained in a gallon of diesel fuel, the primary injection system cannot deliver enough enhanced ethanol to allow an unmodified diesel engine to produce full power. However, by fumigating additional ethanol into the engine, it is able to produce full power, and additive is needed in the fumigated ethanol.

Flexibility of the CIFFE

The CIFFE is flexible as to the fuels that can be used. By putting No. 2 diesel fuel in the primary tank and shutting off the fumigation system, the CIFFE can run entirely on diesel fuel. If the fumigation system is turned on, the governor automatically reduces the consumption of diesel fuel to compensate for the energy added by the fumigated ethanol. If the diesel fuel is drained from the primary tank and replaced by ethanol, the CIFFE will run entirely on the enhanced ethanol, although at reduced power. If enhanced ethanol is injected through the primary system and ordinary ethanol is fumigated, the CIFFE will produce full power.

Performance of the CIFFE

In addition to its flexibility, a noticeable advantage of the CIFFE is that its exhaust is smoke free when running entirely on ethanol. The ethanol also tends to clean any accumulated carbon from the combustion chamber. The fumigation system causes no extra work for the operator except for the need to fill two fuel tanks instead of one. A remaining problem is that the rates of pressure rise in the combustion chamber are well above the norm when running with primary and fumigated ethanol; some additional research is needed to evaluate this problem. Also, no durability tests have been run on the CIFFE.

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